Technologies for Mars Exploration

Chad Edwards,
Manager, Program Formulation Office
Chief Technologist, Mars Exploration Directorate

Jet Propulsion Laboratory
California Institute of Technology

JPL Office of Chief Technologist Retreat, March 13-14, 2018

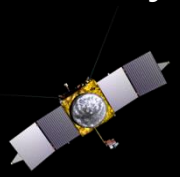
Overview

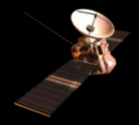
- Technology Drivers: Mission Capability Needs
- Current Technologies Under Development
- New Technology Investment Directions
- Innovation Strategy / Technology Infusion

Mars Exploration Mission Timeline

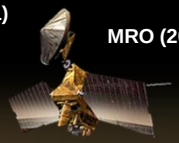
Operational Today

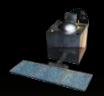

Mars Express (ESA, 2003)


MAVEN (2013)


ExoMars Trace Gas Orbiter (ESA/RSA, 2016)


Odyssey (2001)


MRO (2005)


Mars Orbiter Mission (ISRO, 2013)

2018

2020

Plus…
UAE Hope Orbiter,
China NSCC Orbiter/
Lander/Rover???

Post-2020

Potential Future Pathways:

- *Mars Sample Return Campaign (SRL & SRO)*
- *In Situ Search for Extant Life*
- *Preparing for Human Exploration*


MER Opportunity Rover (2003)


MSL Curiosity Rover (2011)


InSight Lander

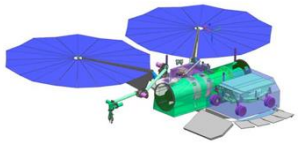

Mars 2020 Rover


ExoMars Rover/Lander (ESA/RSA)

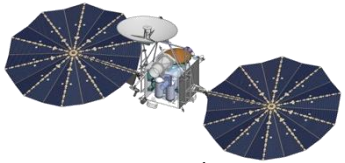
Technology Drivers: Mission Capability Needs

Mars Sample Return

Sample Caching Rover (Mars 2020)



Mars Sample Retrieval Lander



Mars Sample Return Orbiter

Mars Returned Sample Handling (MRSH)

Flight

Ground

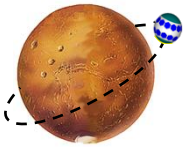
Launch from Earth/Land on Mars → Select Samples → Acquire/Cache Samples

Retrieve/Package Samples on Mars → Launch Samples to Mars Orbit *

Capture and Isolate Sample Container → Return to Earth → Land on Earth *

Retrieve/Quarantine and Preserve Samples on Earth → Assess Hazards → Sample Science

Sample Tube on Mars Surface



Orbiting Sample (OS) in Mars Orbit

Orbiting Sample (OS) on Earth

Sample Science

* Launch order of MSR orbiter and lander mission concepts could be reversed

Technology Drivers: Mission Capability Needs

In Situ Search for Extant Life

- Extreme Terrain Access
- Subsurface Access
- Spacecraft Sterilization for Accessing Special Regions
- In Situ Instruments

Preparing for Human Exploration

- Resource Exploration
- In Situ Resource Utilization
- Environmental Characterization

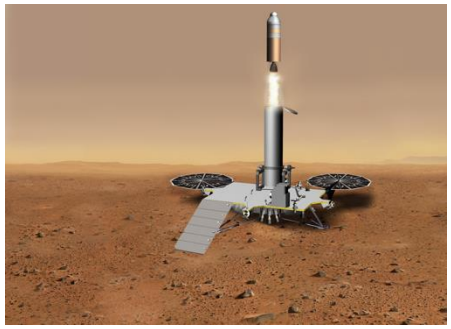
Crosscutting Capability Needs

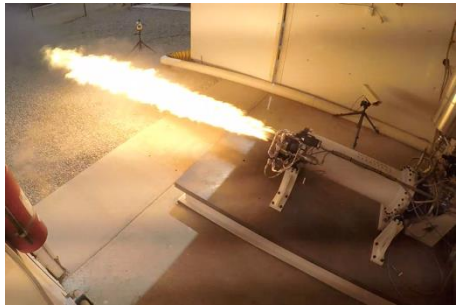
- Entry, Descent, and Landing
- Autonomous Systems
- Telecommunication & Navigation
- Surface Power
- Low-SWaP S/C Concepts
- Planetary Protection

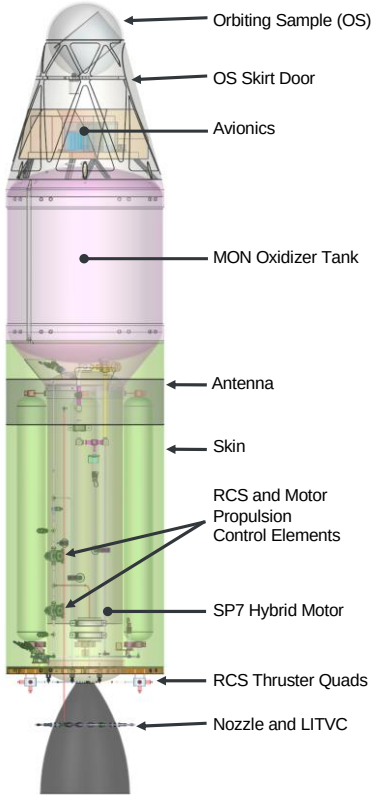
Current Technologies Under Development

Mars Sample Return Lander Concept

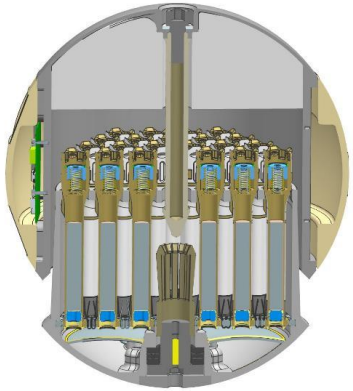
Mars Ascent Vehicle



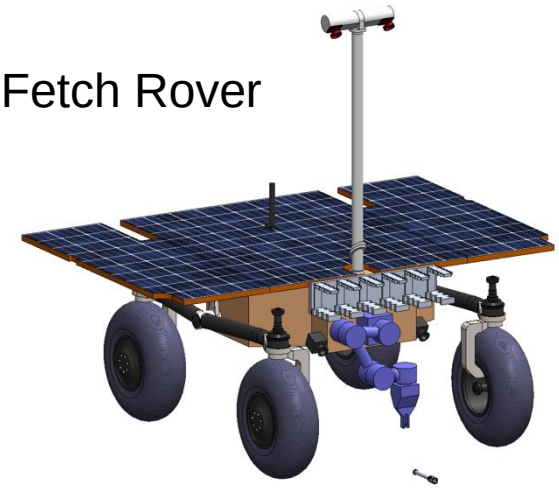


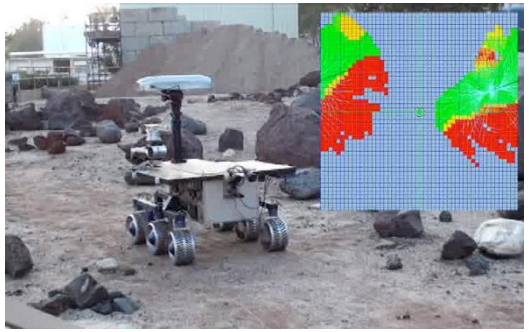


Orbiting Sample (OS) Container



Fetch Rover

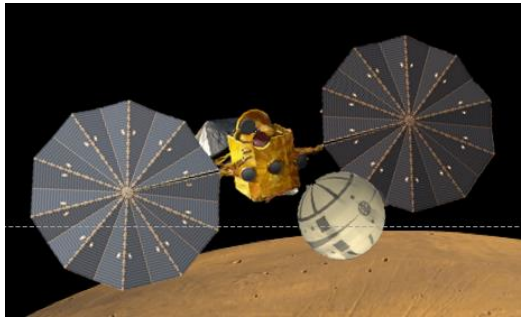


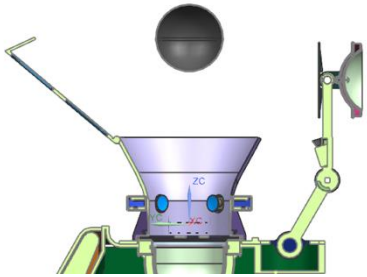


Current Technologies Under Development

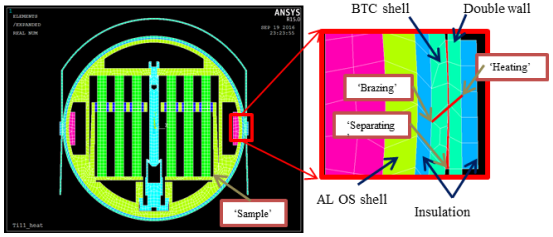
Mars Sample Return Orbiter Concept

On-Orbit Rendezvous & Capture

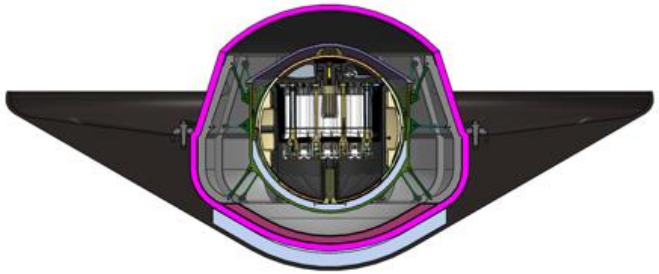




Containment Assurance



Earth Entry Vehicle

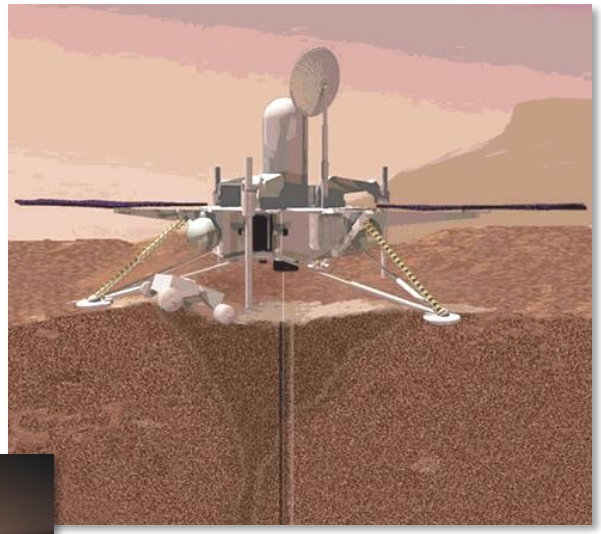


New Technology Investment Directions

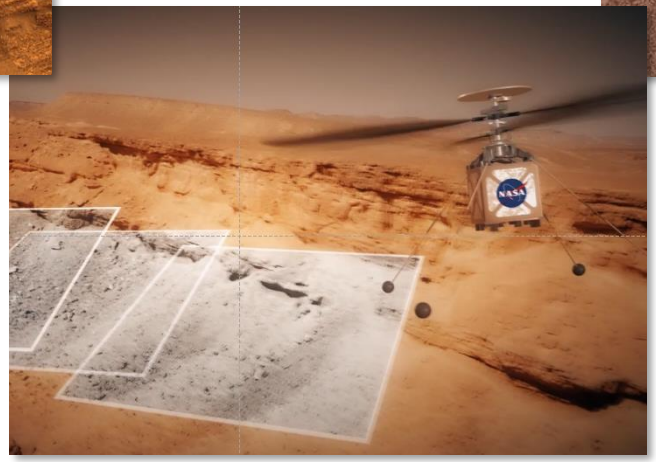
Concepts for New Ways of Accessing Mars

Tethered Rovers

Deep Drilling

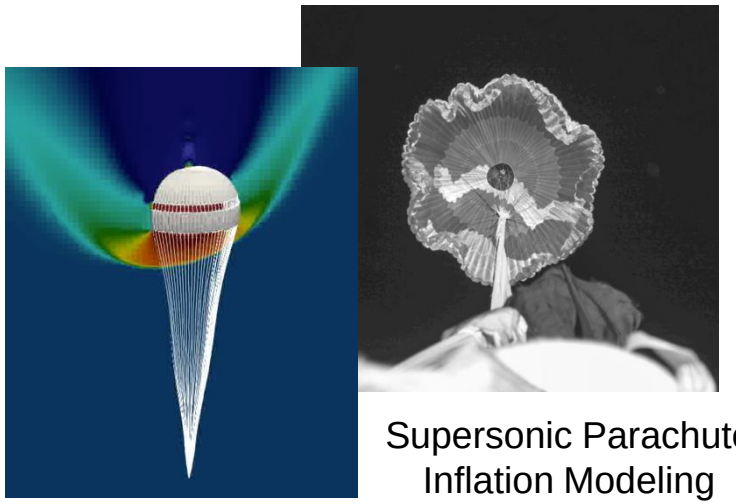


Mars Helicopters

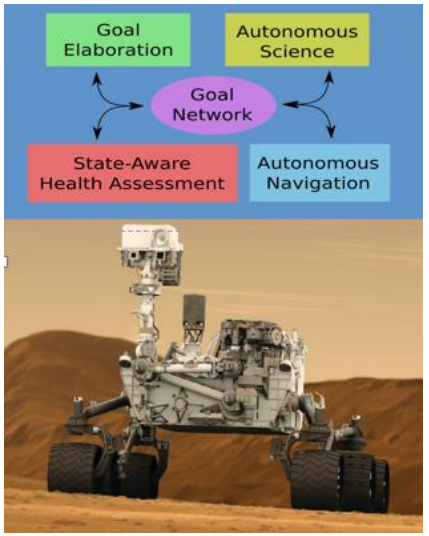


New Technology Investment Directions

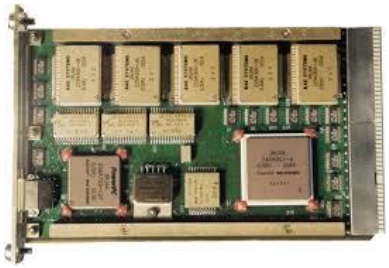
Additional Investment Areas

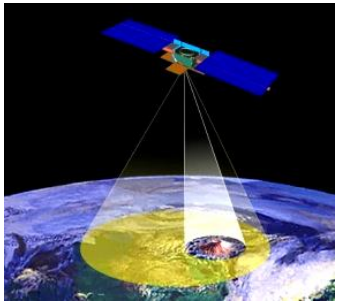


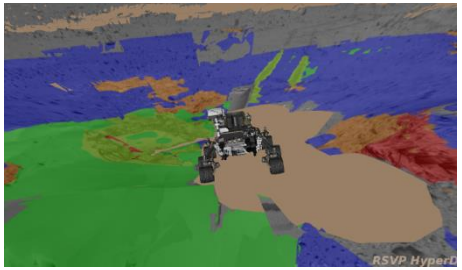
Supersonic Parachute Inflation Modeling



Self-Reliant Rovers







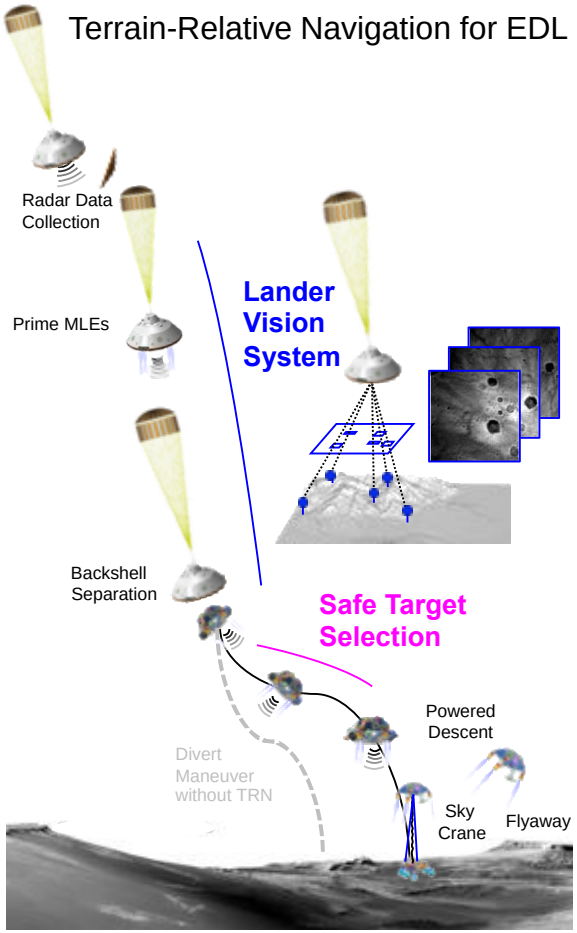
Onboard Analytics for Mars Exploration Enabled by High Performance Spaceflight Computing

Innovation Strategy / Technology Infusion

A number of key technologies have been successfully infused into Mars 2020

Sample Acquisition and Caching

Terrain-Relative Navigation for EDL



Fast Traverse

AEGIS = “Autonomous Exploration for Gathering Increased Science”

Innovation Strategy / Technology Infusion

- Key factors for successful technology infusion:
  - Understand mission capability needs
  - Engage early with targeted project
  - Maintain stable funding through technology development lifecycle
  - Establish mutual agreement with project on definition of “TRL 6”
  - Define visible technology demonstration opportunities to focus development efforts and retire risk
  - Have lead technology developers follow through into flight project implementation

Jet Propulsion Laboratory
California Institute of Technology

jpl.nasa.gov